Wildland-Urban Interface Fires – Experiments and Modeling

National Institute of Standards and Technology

http://www2.bfrl.nist.gov/userpages/wmell/public.html

Building and Fire Research Laboratory

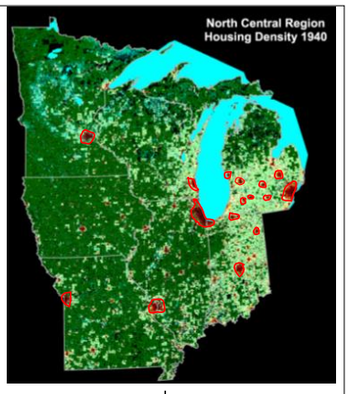
October, 2006

Wildland-Urban Interface (WUI)

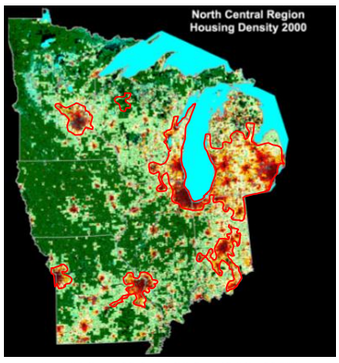
- The WUI is where structures and wildland vegetation coexist.
- 31% homes (41 million) in the lower US states are in the WUI.
- 41% of homes in California are in the WUI, with 3.2 million at significant risk.
- WUI fires can be a significant community threat depending on:
  - environmental conditions (wind, moisture, etc) & topography
  - homeowner landscaping (ornamental vegetation, etc)
  - home design, construction & materials (e.g., brick vs. wood siding)

Problems/Challenges

- The number of structures in WUI settings is increasing rapidly.
- Land managers now regard wildland fire as natural and worthwhile, after decades of attempting total wildfire suppression.
- Prescribed burns are now used to maintain "healthy" wildlands. However, prescribed burns don't always remain "controlled" burns!
- No physics-based model with predictive capability for either wildland or WUI fires exists, despite revolutionary advances in computer performance.
- A multi-person, multi-year research program is needed to develop, verify and validate a predictive, physics-based model



WUI increase ↓ over last 60 years

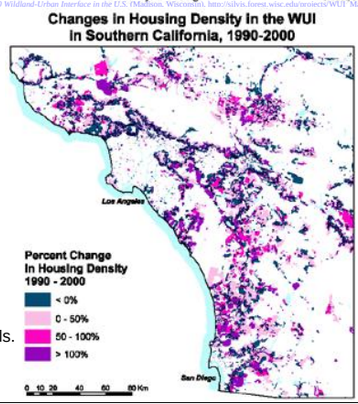


Stewart, S. I., Hammer, R.B., Radeloff, V.C., Dwyer, J.F., & Voss P.R. 2003. Mapping Housing Density across the North Central U.S., 1940-2000 [Slide show]. Available: http://www.ncrs.fs.fed.us/IntegratedPrograms/ic/pop/hd/title.htm

Housing development in the WUI
Is expected to continue to increase.

Objectives

- Develop physics based WUI Fire Dynamics Simulator (WFDS).
- Develop a greater understanding of **fire spread** in different fuels & by different modes:
  - Surface vegetation close to the ground (e.g., grass, brush, leaves & pine needles)
  - Vegetation distributed vertically (e.g., ladder fuels leading to tree canopies)
  - Structural/vegetation fuel intermix
  - Fire spread by burning brands from both vegetation and structures.
- In addition, the model can help to:
  - Evaluate quantitatively the WUI risk-reduction guidelines for homeowners.
  - Assess the risk to a whole community from WUI fire-spread and smoke transport...
  - Plan fire-safe communities.
  - Aid strategic planning for fighting both wildland and WUI fires.
  - Reduce the need for full-scale experiments to validate fire-risk guidelines.
  - Aid the "cross-training" of fire fighters of both structure and vegetation fires using virtual tools.



Preliminary Results and Examples

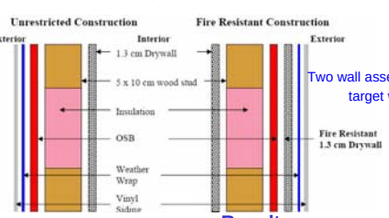
Structure ↔ Structure Fire Spread

- Fire spread depends on construction, windows, separation distance, and weather.
- Brands from structures can enhance fire spread to other structures.
- Some current U.S. residential building codes require only 1.8m (6 ft) separation.

NIST Structure-Separation Studies

- Two "structure" were separated by 1.8 m. In each experiment, a fire initiated in a furnished room broke through a window to impinge on the facing target wall. The two experiments differed by the presence or absence of a fire resistant drywall layer between the oriented strand board (OSB) and exterior layers in the target wall (see figure).

Large Fire Lab experiment



Two wall assemblies for target wall

WFDS computer simulation

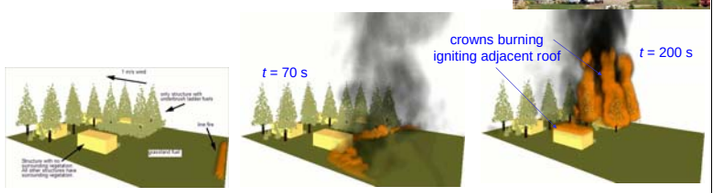
Results

- Without the fire resistant drywall the target wall OSB ignited and burned after 80 s of exposure to flame impingement.
- With the fire resistant drywall the target wall did not ignite after 9 minutes of flame impingement (end of experiment).
- Data will be used to validate FDS predictions of wall ignition and burning.

Vegetation ↔ Structure Fire Spread

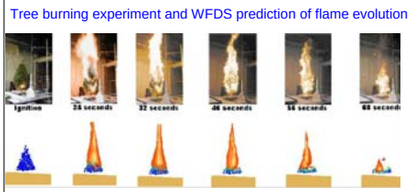
- Simulation (below) of a grass fire approaching a group of structures.
- Far right structure is surrounded by underbrush which allows vertical fire spread from grass to tree crowns which become fully involved.

WUI fire with high vegetation load

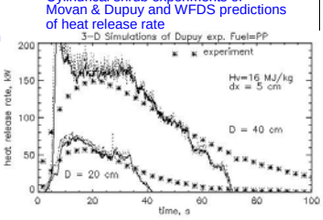


Laboratory experiments of isolated trees and shrubs for model validation of:
- heat release rates
- radiative and convection heat transfer

Tree burning experiment and WFDS prediction of flame evolution

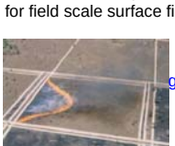


Cylindrical shrub experiments of Movan & Dupuy and WFDS predictions of heat release rate

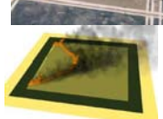


Vegetation ↔ Vegetation Fire Spread

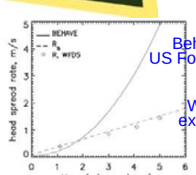
- Grassland fire experiments provide a good first step at validating the computer simulation for field scale surface fires.



Australian grassland exp.



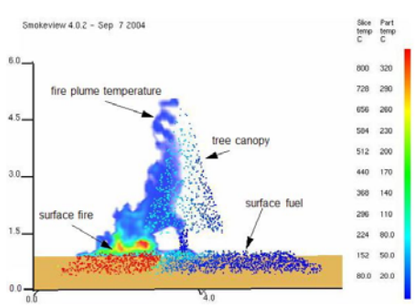
WFDS simulation



BehavePlus US Forest Service

WFDS & experiment

Fire spread from the surface fuel to suspended vegetation is a core component of fire spread.



Ignition from Brands

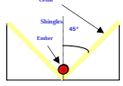
- Successful ignition of structures by windborne burning material (brands) depends heavily on building design (e.g., presence of wood shingles – image at right).
- An experimental wind tunnel apparatus was constructed to test three possible mechanisms of brand initiated fires (*brand initiation and transport was not considered*):
  - pine needles in roof gutters
  - paper in attics
  - structural crevices (shingle overlap)

Brand initiated fire on wood roofing

flaming ignition of pine needles

smoldering ignition of shredded paper

brand in crevice



Findings

- Glowing embers:
  - single embers can ignite paper
  - multiple embers can ignite pine needles
  - multiple embers did not ignite crevices
- Flaming embers:
  - single embers ignite paper and pine needles
  - multiple embers could ignite crevices

Acknowledgments:
This research was partially funded by the USDA Forest Service.

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